APPLICATION OF K-Ɛ MODEL TO COMPOUND CHANNELS HAVING DIVERGING FLOOD PLAINS AND ANALYSIS OF DEPTH AVERAGED VELOCITY USING ANSYS(FLUENT)

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APPLICATION OF K-Ɛ MODEL TO COMPOUND CHANNELS HAVING DIVERGING FLOOD PLAINS AND ANALYSIS OF FLOW PARAMETERS USING ANSYS(FLUENT)

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Based on research carried

out under the supervision of

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ABSTRACT

Water has always been an essential part of civilization and wherever water has been found, civilization flourished. But at the same time this has a downside in the aspect that the increase in population coupled with the man-made dam related failures, landslides etc. has led to an increase in water-related catastrophe in these areas. Hence it is imperative for us to understand the effect of water bodies on its flood plains. When modelling, channels are sub-divided into two types: prismatic channels and non-prismatic channels. A channel is defined as a non-prismatic compound channel when the cross-sectional area throughout the channel is not uniform. It can be further sub-divided into 3 types with respect to the flood plains: converging, diverging and skewed. A channel with divergent flood plains is a type of compound channel where the flood plains eventually diverge out of the main channel. Most studies till now have been carried out on simple and prismatic compound channels while most of real life conditions are not that ideal and take place in non-prismatic channels. This study is done to understand the effects of flood on a non-prismatic diverging channel and the effects it has on the flood plains. Here the goal is to analyze the effectiveness of the k-ε turbulence model in determining the flow parameters of such channels and comparing it experimental results. For this modelling ANSYS-FLUENT is being used. This research has been done by using ADV and pitot tube to calculate the velocities at the main channel and flood plain of the section respectively .The DAV(Depth Averaged Velocity has been found across the width of the channel at different sections . The findings of this work are useful to to validate the k-ε model accuracy in predicting the water flows in diverging channels.

***Keywords*: Modelling Channels; *Diverging Channels*; *ANSYS (FLUENT)*; *k-ε model*; *DAV (Depth Averaged Velocity)*.**

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Chapter 1

INTRODUCTION

1.1 OVERVIEW

Water has always been an essential part of civilization and wherever water has been found, civilization flourished. But at the same time this has a downside in the aspect that the increase in population coupled with the man-made dam related failures, landslides etc. has led to an increase in water-related catastrophe in these areas. Hence it is imperative for us to understand the effect of water bodies on its flood plains. When modelling, channels are sub-divided into two types: prismatic channels and non-prismatic channels. A channel is defined as a non-prismatic compound channel when the cross-sectional area throughout the channel is not uniform. It can be further sub-divided into 3 types with respect to the flood plains: converging, diverging and skewed. A channel with divergent flood plains is a type of compound channel where the flood plains eventually diverge out of the main channel. Most studies till now have been carried out on simple and prismatic compound channels while most of real life conditions are not that ideal and take place in non-prismatic channels. This study is done to understand the effects of flood on a non-prismatic diverging channel and the effects it has on the flood plains. Here the goal is to analyze the effectiveness of the k-ε turbulence model in determining the flow parameters of such channels and comparing it experimental results. For this modelling ANSYS-FLUENT is being used.

1.2 CLASSIFICATION OF CHANNELS FLOW

On base of alteration in flow depth according to time and space open-channel flow can be classified into many types. The open-channel flowi s divided into the four following kinds:

(i) Steady flow and unsteady-flow

(ii) Uniform- flow and non-uniform flow

(iii) Transitional, Laminar and turbulent-flow

(iv) Critical, Sub critical and Super-critical flow

1.3. UNSTEADY FLOW

The unsteady flow in open channel is considered in this research assignment. Deviance of flow depth, flow rate, flow velocity at any section in open channel with respect to time, it is called as an unsteady flow.

Mathematically,

$$\frac{\partial V}{\partial t} \neq 0 \text{ or } \frac{\partial y}{\partial t} \neq 0 \text{ or} \frac{\partial Q}{\partial t} \neq 0 \qquad (1.1)$$

1.4 TYPES OF CHANNELS

There are two sorts of channels: prismatic or non-prismatic. Prismatic channel maintains the geometry all through its length i.e. with a consistent cross-segment, an unvarying base slant, and additional properties for example, wall roughness which doesn't change with the position. This maycontain a trapezoidal-section, a rectangular-section, a circular-section, etc. The channel whose section geometry is consistent althrough the channel. is referred to as a non-prismatic channel. Therefore, mostly man-made channels made from construction resources are prismatic channels, nonetheless portion, like channel shift, will be non-prismatic. In theory the natural channel can possibly be prismatic. Though, in practiceordinary channel is non-prismatic in nature.

1.5 RECTANGULAR CHANNEL

Rectangular channel have vertical sides and base width 'b'. The cross-sectional area is attained after

$$A=b \qquad (1.2)$$

Wetted perimeter is calculated after

$$P= b+2Y \qquad (1.3)$$

Rectangular channel's top width is similar as its basewidth, i.e. T=b. For usage with energy capacity in an open-channel stream, primary moment of area about the surface of water will be signified by Ah_c, also, for rectangle equivalent the area times, the distance between surface of water and centroid of rectangle. It is given by:

$$Ah_c = A\frac{y}{2} = \frac{bY^2}{2} \qquad (1.4)$$

1.6 Compound Channels flow

Compound channels have been utilized in stream designing for a long time in prominence of their significance in natural, biological, and plan issues identified with flood protection plans.

One point of preference of two phase channels in the natural stream, for the most part a main-channel and its flood-plain, is to expand the channel transport amid floods.

1.6.1 Various methods of flow modelling in compound channels

1.6.1.1 Single channel method:

On the basis of the research in the laboratory or field measurements, various empirical formulae have been developed, during 19th century. A formula was proposed by manning (1891), which because of its better predictive ability, was adopted most widely.

$$U = \frac{1}{n} R^{\frac{2}{3}} {S_o}^{\frac{1}{2}} \tag{1.5}$$

$\boldsymbol{U}$ represents the mean flow velocity, the channel bed slope is represented by $\boldsymbol{S_o}$**,** and the Manning’s coefficient factor is taken as 1/n.

1.6.1.2. Divided channel method:

It was suggested by Lotter (1933) that separating the cross-section of the channel into different sub-sections where homogeneity of velocities are more, mainly the main-channel and the two flood-plains. Estimation of discharge in every subsection is done separately. The total discharge Q is then calculated by adding the sub-section Q_i.

$$Q = \sum_i Q_i = \sum_i \frac{A_i {R_i}^{2/3}}{n_i} {S_o}^{1/2} \tag{1.6}$$

Here, the subscript i represents the subsection i. This method, is known as the divided channel method (DCM).

1.7 PRISMATIC AND NON-PRISMATIC COMPOUND CHANNELS

A compound channel with non-varying cross-section and non-varying bottom slope is termed as prismatic compound channel. Most of the artificial compound channels are designed as prismatic compound channels. The general geometry used for designing the prismatic compound channels is like rectangular, parabola, circle or trapezoid are the normally used shapes of prismatic compound channels. The flow in prismatic compound channels will be steady flow and uniform flow as the cross section and bed slope of the channel is not changing. A non-prismatic compound section is the one either cross-section or slope or both cross-section and slope changes the channel is termed as non-prismatic compound section. It is very clear that only the artificial channel can be prismatic sections because of its irregular shapes which is caused by nature.

1.8 CONVERGING COMPOUND CHANNELS

Converging channel is a type of non-prismatic compound channel whose flood plain varies along its length. At certain length of the channel the width of the flood plain starts decreasing and converges into main channel. The flow in this type of compound channel is not uniform flow but the flow is steady across the channel.

1.9 SKEWED COMPOUND CHANNELS

This is also a type of non-prismatic compound channel whose geometry is not of a regular shape .The shape of the channel is a kind of twisted along its length but the width of the flood does not converges or diverges along the length, it remains constant. The flow in this type of compound channel is not uniform flow but the flow is steady across the channel.

1.10 DIVERGING COMPOUND CHANNELS

Diverging channel is a type of non-prismatic compound channel which are divided into three types namely diverging channel, converging channel and skewed channel. A diverging channel is a type of compound channel whose floodplain starts to deviate or diverge from the main channel is termed as Diverging compound channel. Present project work is worked on non-prismatic diverging compound channel whose diverging angle as 6 degree and the deviation of compound channel starts from 9m from the inlet. The length of diverging section is 5m i.e., 9m from the inlet to 13m. As diverging angle of the compound section

1.11 ANSYS (FLUENT)

'Analysis of Systems' or ANSYS, as it is regularly alluded to, is a simulation software that permits clients to outline structures and perform investigation in a virtual domain in various streams, for example, fluid dynamics, structural mechanics, electromagnetics, hydro-dynamics etc. ANSYS FLUENT is a part of the ANSYS CFD pack which considers reenactment of liquid streams in a virtual domain, for example, water coursing through a channel, streamlined features and so on. It is a 3-D programming that utilizes "meshing" to perform its computations. Meshing includes separating the body of the structure into little segments, perform investigation on every individual part lastly gives us the outcome by summation of these qualities utilizing limited component strategies.

ANSYS Fluent, is based on CFD (Computational Fluid Dynamics) which is used to analyse fluid flows and fluid behavior in various cases .This can create a virtual environment to understand the virtual environment of simulation of flow like the turbine engines aerodynamic pumps. ANSYS is being used for designing many other practical applications in the field of fluid dynamics. It creates an environment of a situation such that it clearly explains the practical situation of all the conditions of the flow behavior .There are lot of customizations options in it to design the channels as practically as possible.

Chapter 2

LITERATURE REVIEW

2.1 LITERATURE REVIEW

Toebes and Sooky (1967) were most likely the first to examine under research center conditions the power through pressure of winding streams with floodplains. They endeavored to relate the vitality loss of the watched interior stream structure connected with association between channel and floodplain streams. The complexity of helicoidal channel stream and shear at the even interface between principle channel and floodplain streams were explored. The vitality misfortune per unit length for winding channel was up to 2.5 times as substantial as those for a uniform channel of same width and for the same water powered range and release. It was likewise found that vitality misfortune in the compound winding channel was more than the aggregate of basic wandering channel and uniform channel conveying the same aggregate release and same wetted edge. The collaboration misfortune expanded with diminishing mean speeds and showed a most extreme when the profundity of stream over the floodplain was less. With the end goal of examination, an even liquid limit situated at the level of primary channel bank full stage was proposed as the best other option to separate the compound channel into water driven homogeneous areas. Hellicoidal streams in wind floodplain geometry were seen to appear as something else and more declared than those happening in a wind direct conveying in bank stream. Reynold's number (R) and Froude number (F) had noteworthy impact on the winding channel stream.

Myers and Elsawy(1975) explained that maximum shear stress is developed at the main channel and flood plain interface due to development of a local velocity acceleration as a result of a transfer of momentum.

Ghosh and Kar (1975) stated the assessment of interaction result and delivery of boundary shear stress in the meander channel having floodplain. By relationship proposed by Toebes & Sooky (1967) assessed interaction result by parameter (W). The interface loss amplified up to a certain floodplain depth and then it reduced. They decided that the channel shape and roughness did not have Influence on the interaction losses of fluid flow.

Knight and Dimitriou(1983) studied characteristics such as velocity, discharge, boundary shear stress etc. in prismatic compound sections consisting of a rectangular and two symmetric flood plains. The findings state that the shear force on the vertical interface between the main channel and flood plains increases for lower relative depths and wider flood plains.

Tominaga et al. (1988) suggested the influence of secondary currents in distribution of velocity, boundary shear stress and the 3-D bed configuration in open channel flows. An examination of three-dimensional (3-D) turbulent structure, incorporating turbulence-driven auxiliary streams in compound open-channel streams, is a vital subject in pressure driven and waterway designing, and in liquid mechanics. In this study, exact estimations in completely created compound open-channel streams are led by method for a fiber-optic laser Doppler anemometer. Optional speeds can be measured precisely with the present 3-D estimation framework. The attributes of compound open-channel streams are perceived in the intersection district between the fundamental channel and surge plain, though the qualities of rectangular open-channel streams are seen in a locale close to the sidewall of the primary channel. Solid, slanted optional streams, which are connected with a couple of longitudinal vortices, are produced in the intersection district between the fundamental channel and the surge plain. The essential mean speed field is straightforwardly affected by these auxiliary streams. Turbulence intensities and the Reynolds anxieties are likewise uncovered in point of interest. Also, the impacts of channel geometry and bed harshness on turbulent structure are analyzed.

Tominaga and Nezu(1991) elucidated that a high shear layer is formed at the interface between the main channel and the flood plain due to interaction of the swifter flows in the main channels and the relatively slower moving flows in the flood plains. This leads to the formation of large scale vortices with vertical axes as well as helical horizontal flow.

Shino and Knight(1991) carried out extensive research on the secondary current flow in prismatic channels. Emphasis was given on the influence on the edge between the main channel and the flood plains. The structure of the currents formed was also highlighted completed release estimations for over bank stream in a two-phase winding channel with different bed inclines, sinuosities, and water profundities. The impact of bed incline and sinuosity on release was observed to be noteworthy. A basic outline condition for the movement limit taking into account dimensional examination is proposed. This condition might be utilized to evaluate the stage-release bend in a wandering channel with over bank stream. Expectations of release utilizing existing techniques and the proposed strategy are thought about and tried against the new measured release information and other accessible over bank information. The qualities also, shortcomings of the different techniques are talked about.

Ervine and Jasem(1995) found out that in skewed compound channels , there is a reduction in conveyance as compared to prismatic channels. Also, the velocity of the main channel is mostly constant throughout the channel decreasing slightly towards the end suggesting a process of substitution due to cross over flow.

Wormleaton(1996)stated that the shear layer formed between the main channel and flood plains extends over the flood plains' width and its value decreases towards the flood plain wall reducing to zero at the walls

Patra and Kar (2000) reported the test outcomes concerning the limit shear stress, shear drive, and release qualities of compound wandering waterway areas made out of a rectangular principle channel and maybe a couple floodplains arranged off to its sides. They utilized five dimensionless channel parameters to shape conditions speaking to the aggregate shear power rate conveyed by floodplains. An arrangement of smooth and unpleasant segments is studied with a perspective proportion shifting from 2 to 5. Clear shear strengths on the expected vertical, slanting, and even interface fields are observed to be not quite the same as zero at low profundities of stream and change sign with an expansion inside and out over the floodplain. A variable-slanted interface is proposed for which evident shear power is computed as zero. Conditions are introduced giving extent of release conveyed by the fundamental channel and floodplain. The conditions concurred well with test and waterway release information

Patra and Kar (2004) reported the test outcomes concerning the speed dispersion of compound wandering waterway areas made out of a rectangular fundamental channel and maybe a couple floodplains arranged off to its sides. They utilized dimensionless channel parameters to shape conditions speaking to the rate of stream conveyed by floodplains and fundamental channel sub segments.

Bousmar et al.(2006) studied compound flood plains with symmetrically diverging flood plains with varying angles of divergence and the effects of divergence on parameters like velocity , stress distribution etc.

Khatua(2007)focused on the use of different methods like SCM, DCM, Area method, Cohrence method to explain effect of depth variation, loss of energy, boundary shear formation in main channels and finally discharge prediction.

Proust, Bousmer, Riviere and Zech(2009) carried out research in non-uniform flow in compound non-prismatic channels using a one dimensional method to assess the distribution of discharge over the channel. A new methodology called Independent sub-sections method(ISM) was developed to calculate non-uniform flow in compound channels.

Chlebek(2009) carried out further research on skewed compound channels at different skew angles, observing differences in flow in the various subsections leading to uneven distributions in flow over the main channel and the flood plains. Also Shino and Knight (SKM) method was used to analyze flow in prismatic flood plains.

Yonesi et al(2013) concerned with the velocity distribution , percentage divided discharge, shear stress, secondary flow, friction factor, secondary flow and turbulence effect on the water flow in the non-prismatic compound channel with varied roughness on the bed of the channel and for three divergent angles.

Das et al. (2015) showed that change in cross-sections at different depths effects conveyance of flow using methods like single channel method (SCM), divided channel method (DCM) in the prediction of discharge in non-prismatic converging and skew compound channels.

2.2 CRITICAL REVIEW:

From the above literature survey, the following critical reviews are summarized:

- Very few papers were published on compound channels with diverging flood plains.
- Sufficient experimental datasets are not available to model the flow in such channels.
- No models were found to evaluate the flow parameters in diverging compound channels.
- For high relative depth, there is no traditional method to predict the discharge in compound channels with diverging floodplains.
- Effect of turbulence kinetic energy(k) and energy dissipation(ε) has not been discussed for diverging compound channels.

2.3 OBJECTIVE OF WORK:

The objective of the work is to analyze the flow in compound channel having diverging floodplains using the k-ε turbulence model and to know the effect of different diverging angles in the flow parameters like depth averaged velocity and the boundary shear stress.

The above objective is accomplished by the following steps:

- To model the compound channel having diverging flood plains with varying angles in ANSYS (FLUENT).

- Experimentation to be done on the compound channel with diverging floodplain having 6 degree to validate the results found from ANSYS (FLUENT).
- Collecting the data from existing research on diverging compound channel with different angles of divergence.
- To learn the accuracy of the k-ε model in prediction of the flow parameters for the compound channel having diverging floodplains.

CHAPTER 3

METHODOLOGY

3.1 METHODOLOGY

Different turbulence models are available to study the flow in non-prismatic channels. Most notable methods are the two-equation models, shear stress turbulence (SST) models and Large Eddy Simulation models. Among the two-equation models, we have the Large Eddy Simulation models. In this study, we have focused on the k-ε turbulence model (provided by ANSYS) for our current research.

3.2 K-Epsilon (k-ε) TURBULENCE MODEL

K-epsilon (k-ε) turbulence model is the most widely recognized model utilized as a part of Computational Fluid Dynamics (CFD) to reproduce mean stream attributes for turbulent stream conditions. It is a two condition model which gives a general portrayal of turbulence by method for two incomplete differential equations.

The turbulence length scale is a physical amount portraying the measure of the substantial vitality containing vortexes in a turbulent stream. The turbulent length scale is frequently used to gauge the turbulent properties on the deltas of a CFD reproduction.

In the k-ε model the turbulent length scale can be calculated as:

$$l = C_\mu k^{3/2}/\varepsilon \qquad (3.1)$$

C_μ is constant in k-ε turbulence model has a value of 0.09.

For turbulent kinetic energy k,

$$\frac{\partial(\rho k)}{\partial t} + \frac{\partial(\rho k u)}{\partial x} = \frac{\partial}{\partial x}\left[\frac{\mu}{\sigma}\,\frac{\partial k}{\partial x}\right] + 2\mu EE - \rho\varepsilon \qquad (3.2)$$

For dissipation ϵ,

$$\frac{\partial(\rho\varepsilon)}{\partial t} + \frac{\partial(\rho\varepsilon u)}{\partial x} = \frac{\partial}{\partial x}\left[\frac{\mu}{\sigma}\,\frac{\partial\varepsilon}{\partial x}\right] + C\frac{\varepsilon}{k}\,2\mu EE - C_{2\varepsilon}\rho\frac{\varepsilon^2}{k} \qquad (3.3)$$

Where μ represents velocity component in corresponding direction, E_{ij} represents component of rate of deformation, μ reresents the eddy viscosity.

$$\mu_t = \rho C_\mu \frac{k^2}{\varepsilon} \qquad (3.4)$$

$C_\mu = 0.09$, $\sigma_k = 1.00$, $\sigma_\varepsilon = 1.3$, $C_{1\varepsilon} = 1.44$, $C_{2\varepsilon} = 1.92$

$$\varepsilon(t) = \frac{L(t) - L}{L} \qquad (3.5)$$

Strain rate (Rate of deformation) is given by,

$$\varepsilon(t) = \frac{d\varepsilon}{dt} = \frac{d}{dx}\left(\frac{L(t)-L}{L}\right) = \frac{1}{L}\frac{dL}{dt}(t) = v(t)/L \tag{3.6}$$

3.3 MEASUREMENT OF DEPTH AVERAGED VELOCITY (DAV)

The depth averaged velocity is defined as average of the velocities taken at different depths at single point of the channel

3.3.1 Calculation of DAV in the main channel

In case of main channel the velocities are recorded or calculated by ADV (Acoustic Doppler Velocitimeter). At each depth of certain point in the channel three thousand samples are recorded, the average of all these samples is taken as the velocity at that point. Likewise, the velocities are calculated for entire depth of that point and averages of those velocities is termed as Depth Averaged Velocity (DAV).

The ADV needs minimum 5cm of water to detect the water flow and velocity of the water in the channel. That's why there is need for two ADV's one is up probe and the other is down probe to cover the entire depth of the channel for the calculation of velocity.

3.3.2 Calculation of DAV in the flood plain

The usage of ADV is not possible here because the ADV needs minimum 5cm water depth to detect the water velocity ,as the water depth is very low at the flood plain section ADV's cannot be used at the flood plain. Calculation of DAV at this part can be done by using Pitot tube by measuring the difference between static and dynamic pressures, the inclination of the pitot is considered in the calculation of velocity of the water. The readings are taken at an interval of one minute.

3.4 EXPERIMENTAL SETUP

The whole experimental setup comprises of three parts overhead tank, compound channel and volumetric tank. The water required for the experiment is supplied from the overhead tank using two electric motors and the tank is situated at a height of 3.5-4.5 meters.

For the current research work, the experiment is conducted at NIT Rourkela for compound channel having diverging floodplain having angle 6 degree. The size of NITR flume is 20m× 2m×0.5m having bed slope 0.002. Divergence starts at 9m from the inlet. The total width at the inlet of channel is 0.94m, depth of the main channel is 11.3cm and the width of the main channel is 0.34m.

The water after running through the compound channel is collected in a volumetric tank whose volume is known, the discharge of the flow can be calculated. The sample figure of experimental setup is shown below:

Fig.3.3 Experimental Setup

CHAPTER 4

NUMERICAL EXPERIMENTATION IN ANSYS

4.1 NUMERICAL EXPERIMENTATION IN ANSYS

Analysis in ANSYS (FLUENT) is done in five step process. They are:

1. GEOMETRY: Geometry of the experimental setup has made in ANSYS specifying each and every dimensions like length , width , depth , length of diverging section and the diverging angle , in this case it is 6 degrees .
2. MESHING: Meshing is the process of analysing whole body of channel section by dividing it into numerous small individual rectangular portions. There are many types of meshing's are there for the current project rectangular meshing has been used.
3. SETUP: Setup section includes the entering all the parameters and constants that are required for analysing the channel flow.
4. SOLUTION: Solution sections is to run the software to get the results after doing geometry, meshing, and setup of the channel.
5. RESULT: This is the last and final stage to analyse the channel .This where we can get the results in form of counters, animation videos, graphs. We can extract the data and draw the graphs separately.

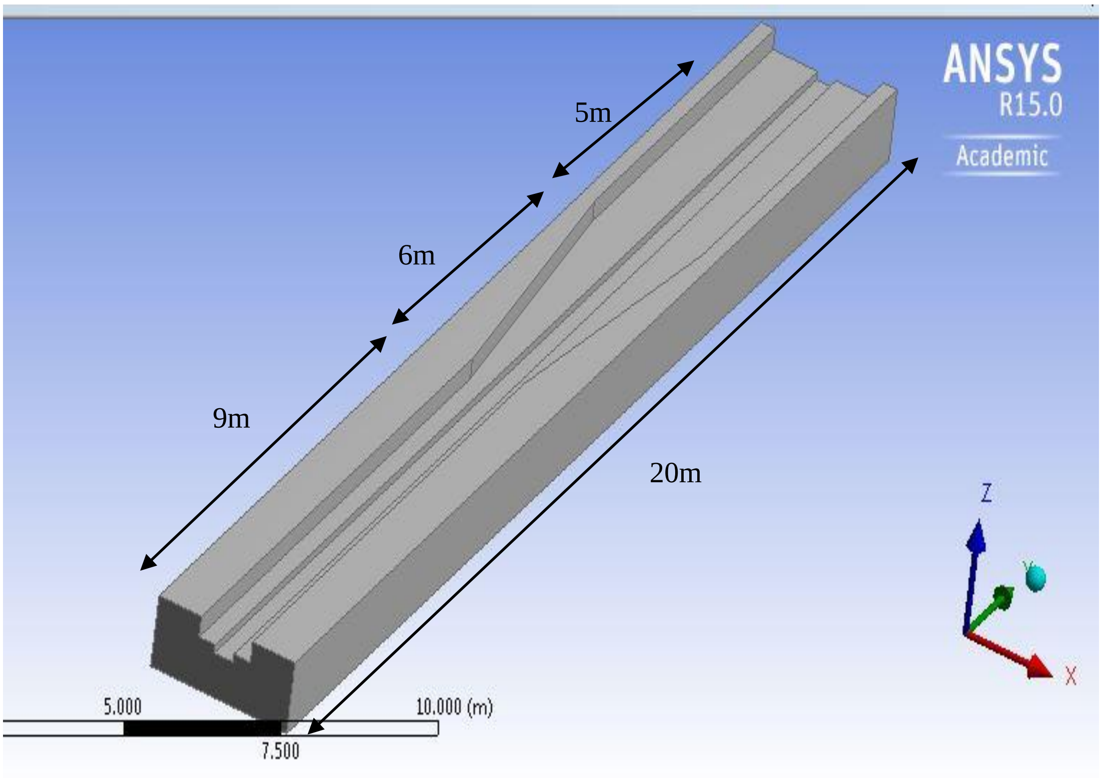

Fig.4.1 Image for diverging angle 6° made in ANSYS.

4.2 ANALYSIS IN ANSYS

Velocity counters are made at different sections 8m, 9m , 10m , 11m , 12m , and 13m from the inlet for various relative depths like 0.2 and 0.35 .

4.2.1 for 0.2 relative depth

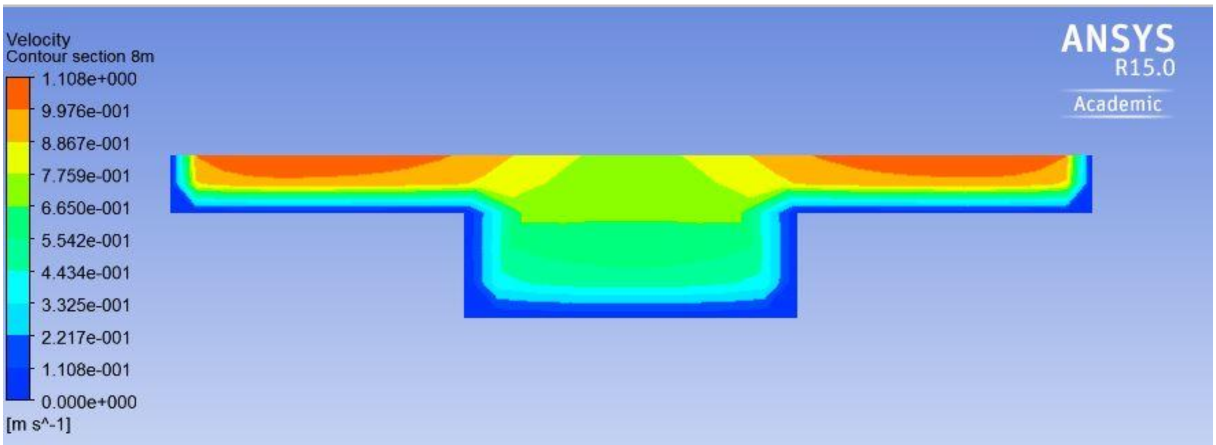

Fig.4.2 Velocity contour at 8m from inlet for Dr = 0.2

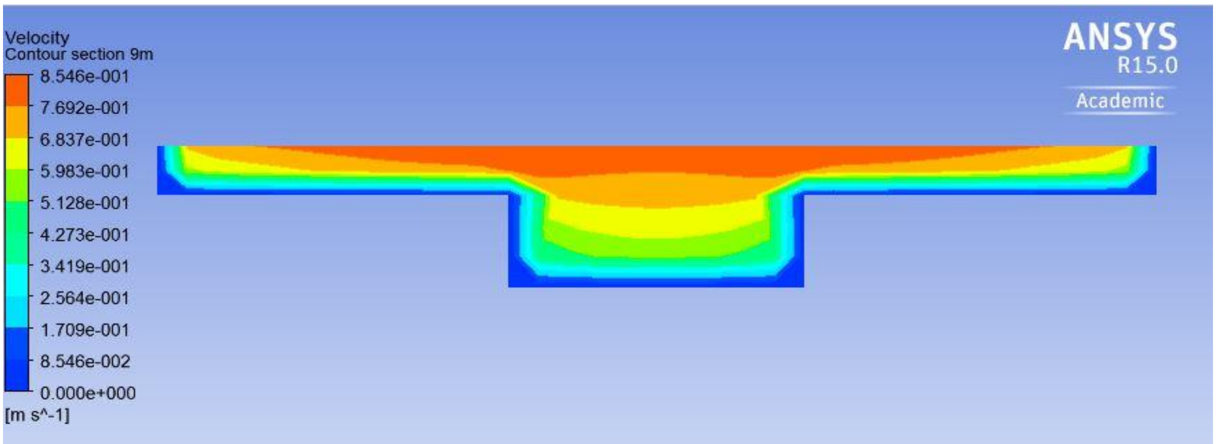

Fig.4.3 Velocity contour at 9m from inlet for Dr = 0.2

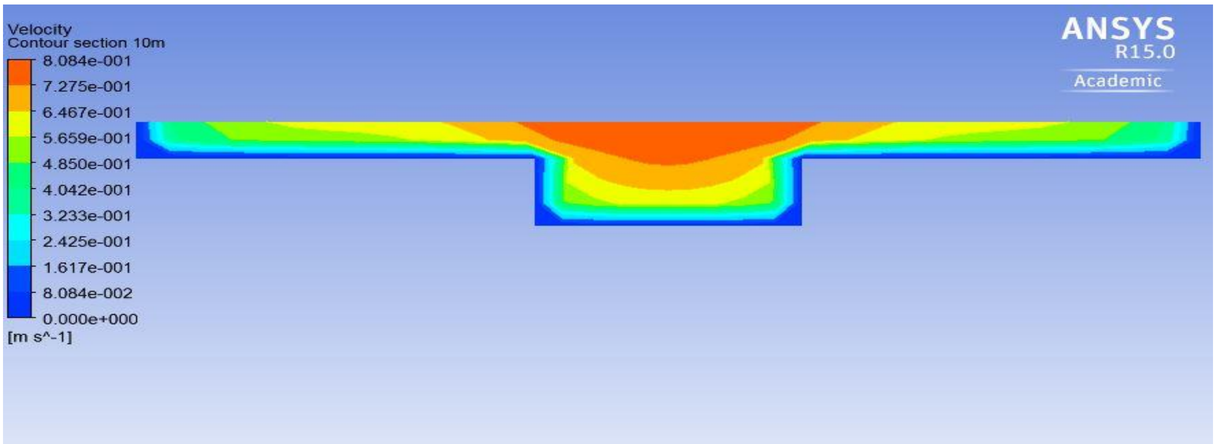

Fig.4.4 Velocity contour at 10m from inlet for Dr = 0.2

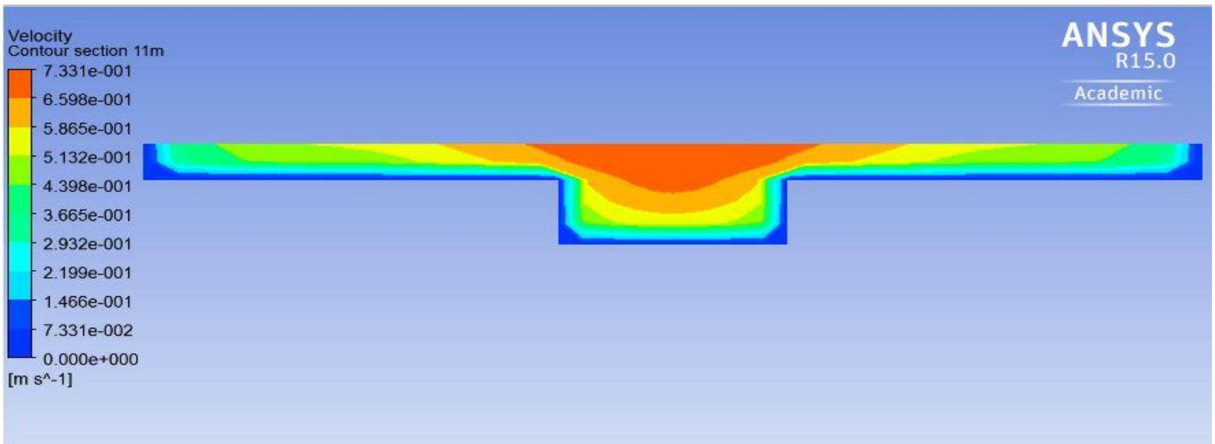

Fig.4.5 Velocity contour at 11m from inlet for Dr = 0.2

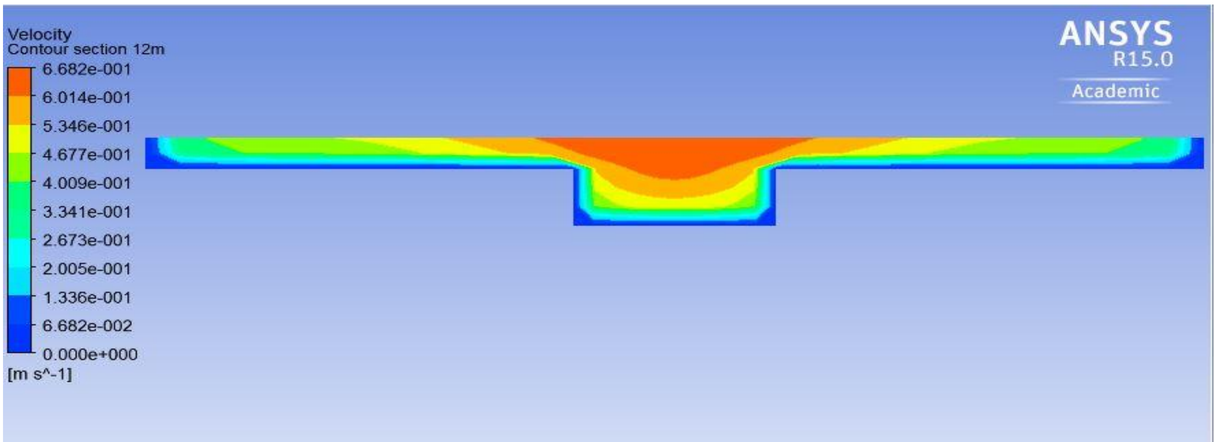

Fig.4.6 Velocity contour at 12m from inlet for Dr = 0.2

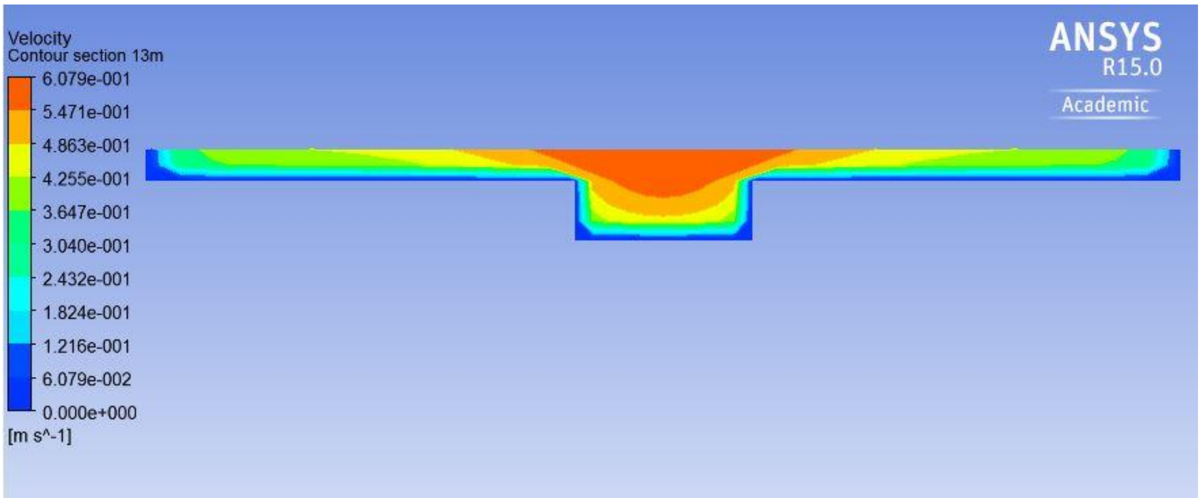

Fig.4.7 Velocity contour at 13m from inlet for Dr = 0.2

4.2.2 For 0.25 relative depth

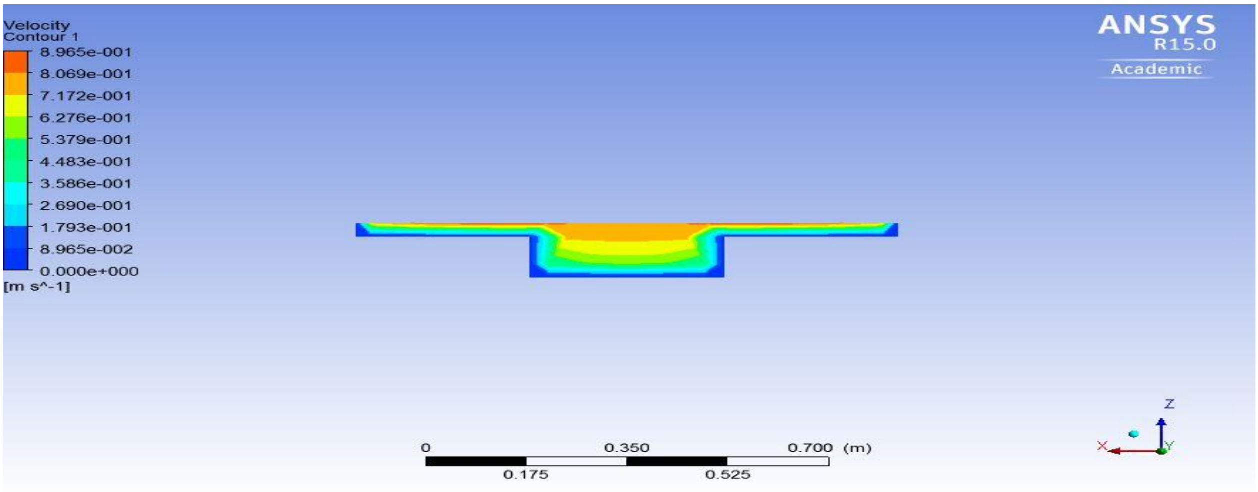

Fig.4.8 Velocity contour at 8m from inlet for Dr = 0.25

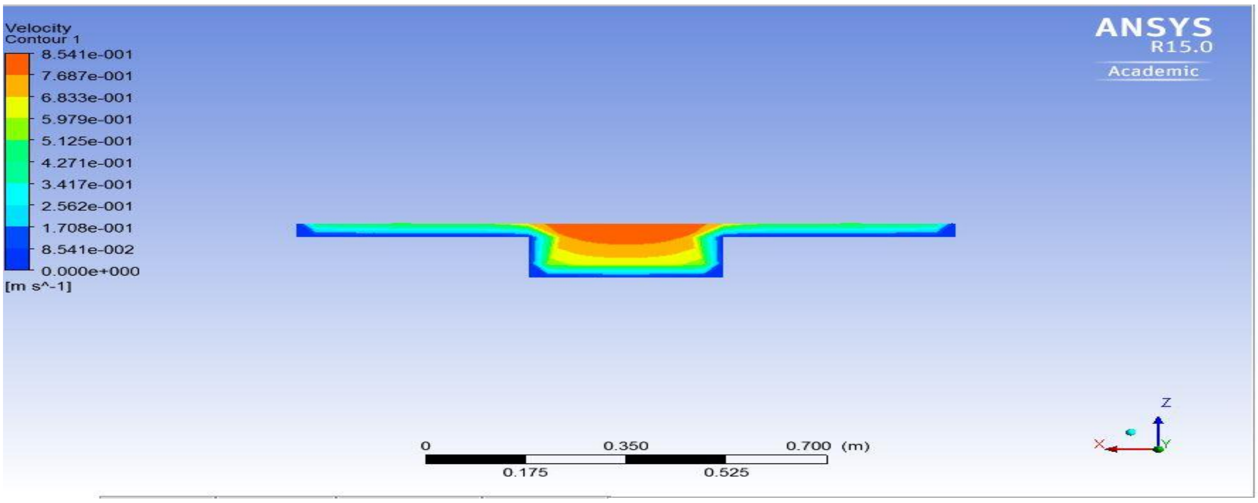

Fig.4.9 Velocity contour at 9m from inlet for Dr = 0.25

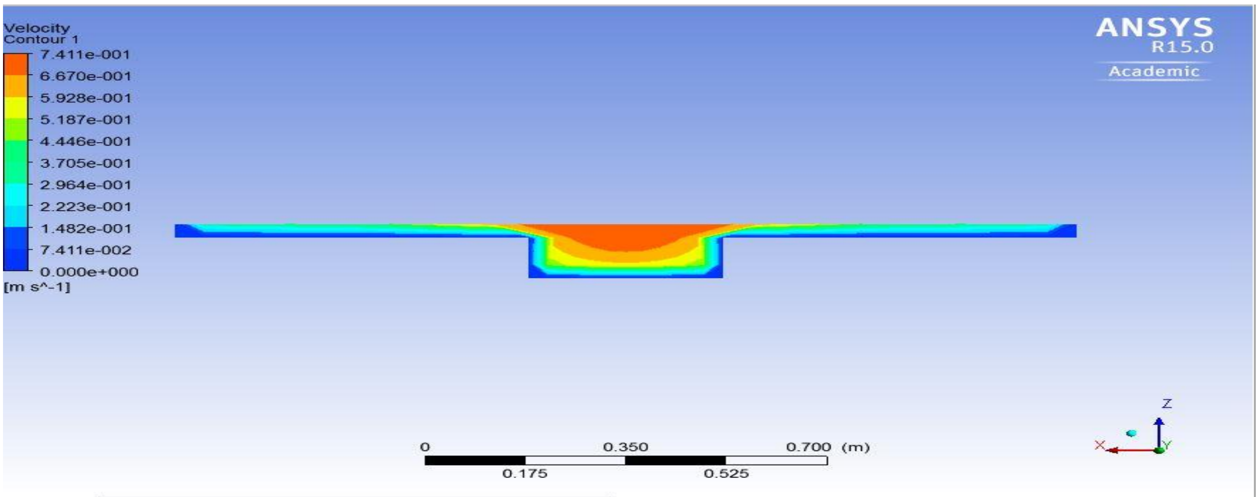

Fig.4.10 Velocity contour at 10m from inlet for Dr = 0.25

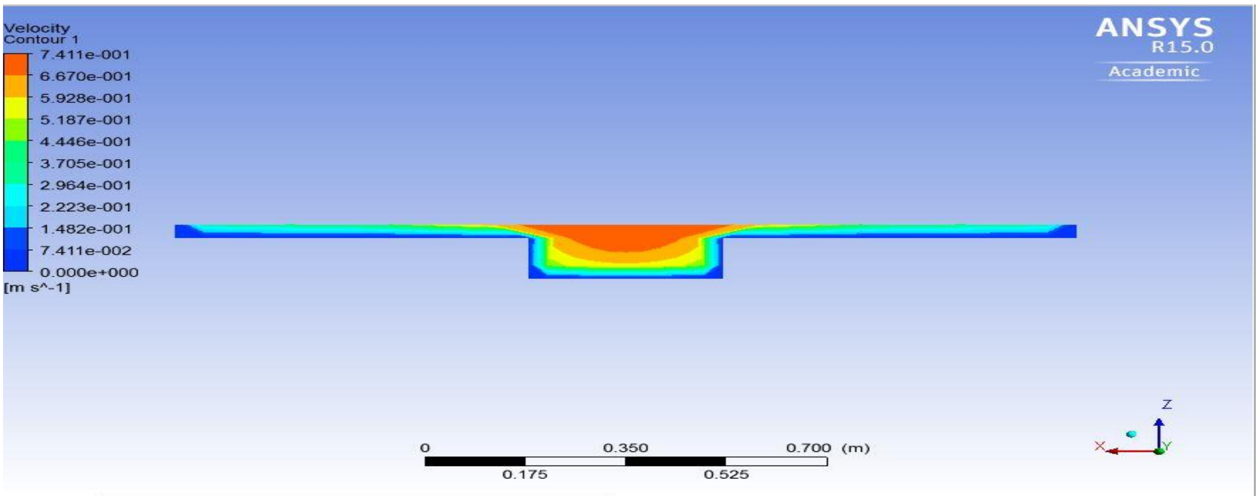

Fig.4.11 Velocity contour at 11m from inlet for Dr = 0.25

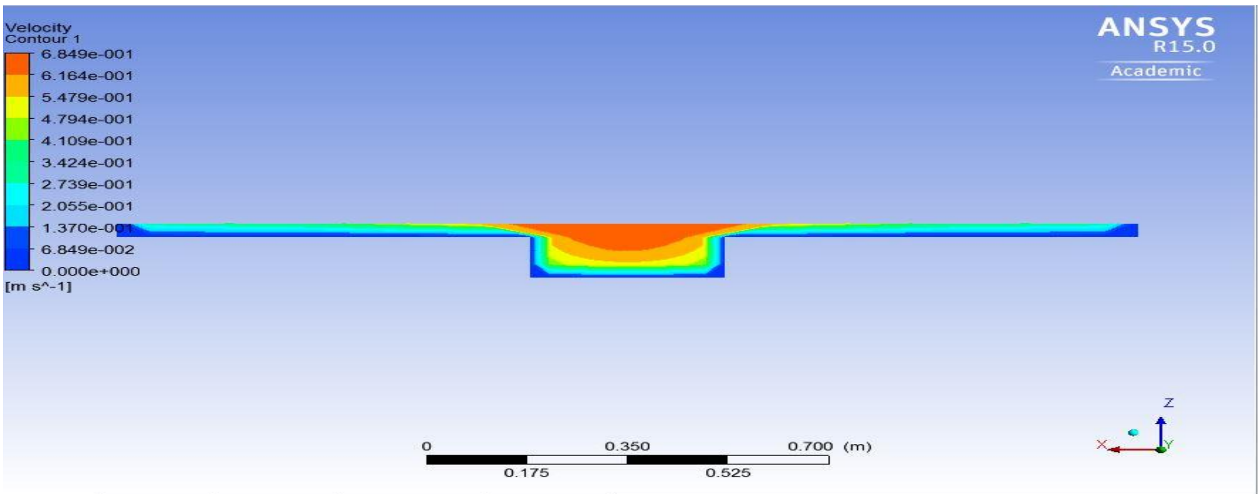

Fig.4.12 Velocity contour at 12m from inlet for Dr = 0.25

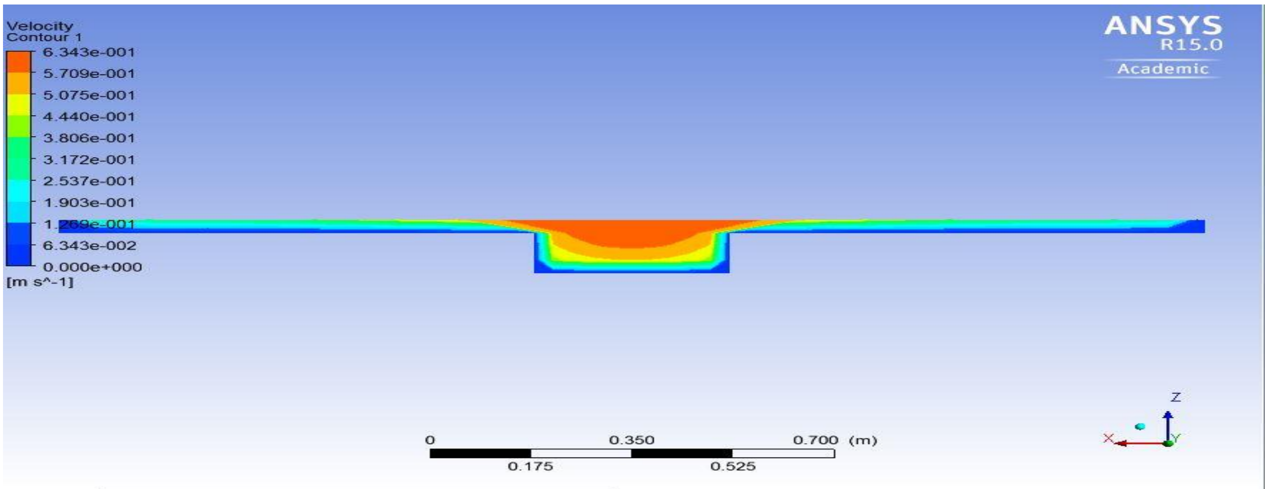

Fig.4.13 Velocity contour at 13m from inlet for Dr = 0.25

4.2.3 For 0.35 relative depth

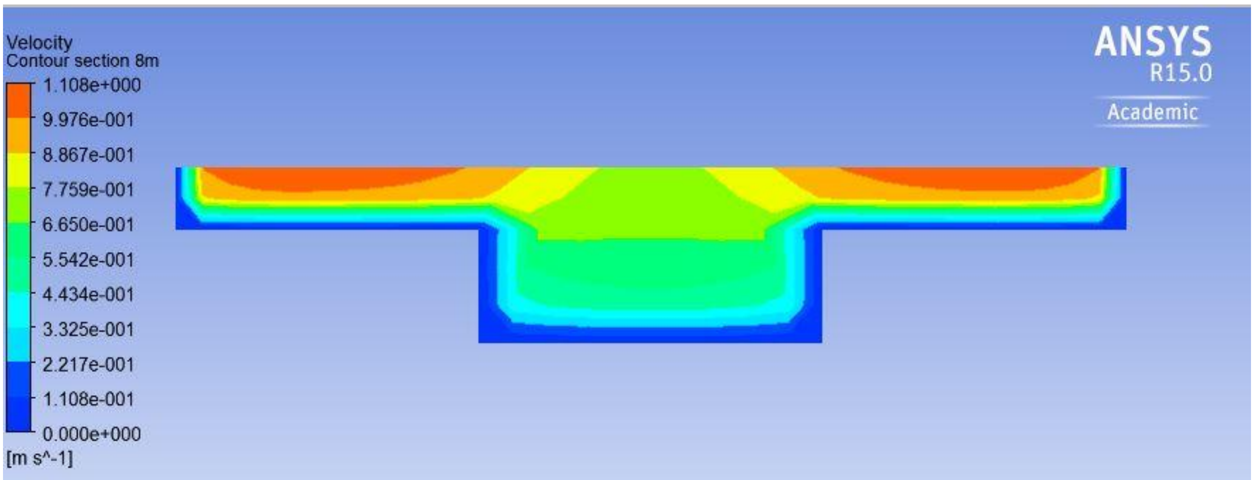

Fig.4.14 Velocity contour at 8m from inlet for Dr = 0.35

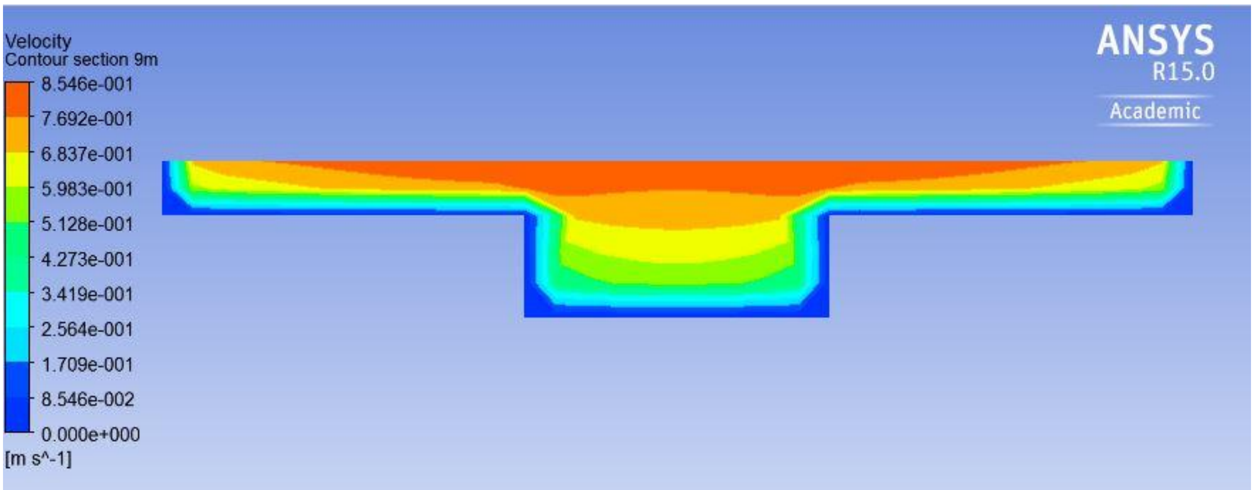

Fig.4.15 Velocity contour at 9m from inlet for Dr = 0.35

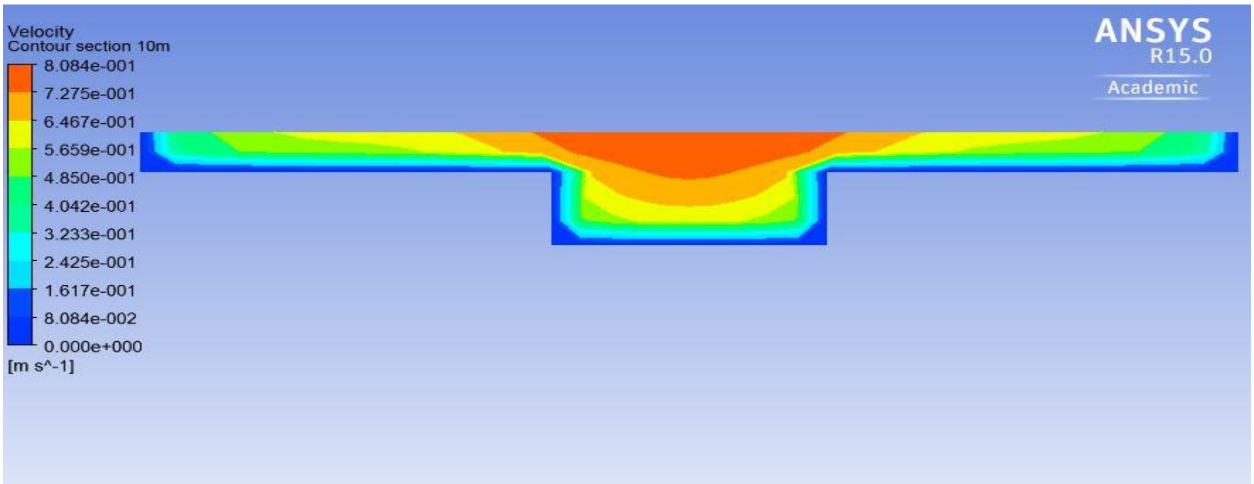

Fig.4.16 Velocity contour at 10m from inlet for Dr = 0.35

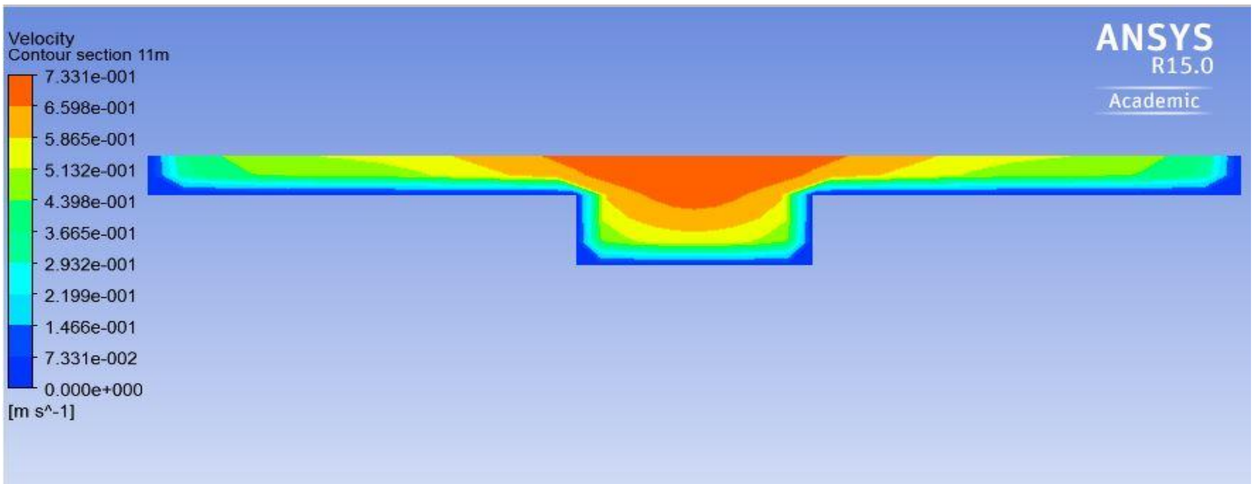

Fig.4.17 Velocity contour at 11m from inlet for Dr = 0.35

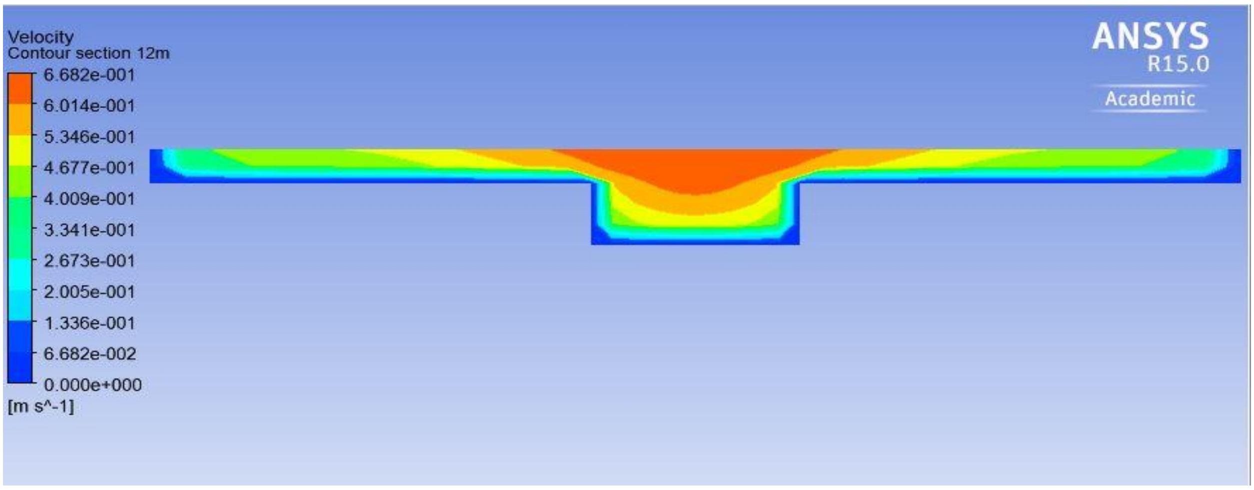

Fig 4.18 Velocity contour at 12m from inlet for Dr = 0.35

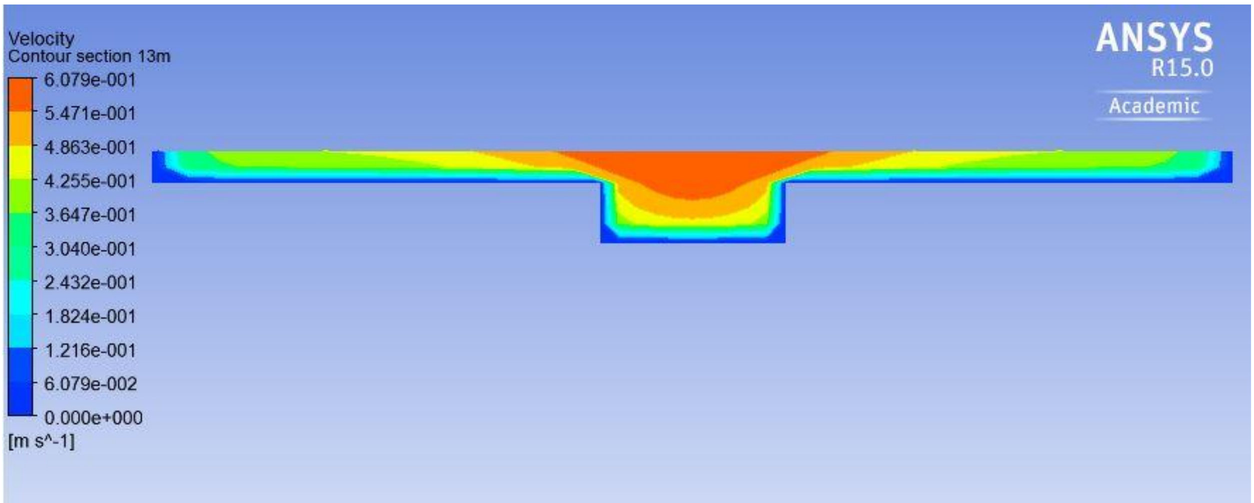

Fig 4.19 Velocity contour at 13m from inlet for Dr = 0.35

4.3 GRAPHS

These graphs are drawn from the data extracted from ANSYS. In this graphs it is shown that that how the Depth Averaged Velocity (DAV) changes along the width of the channel at different sections of the channel like 8m , 9m 10m , 11m , 12m and 13m from the inlet of the channel for different relative depths .

4.3.1 For 0.2 relative depth

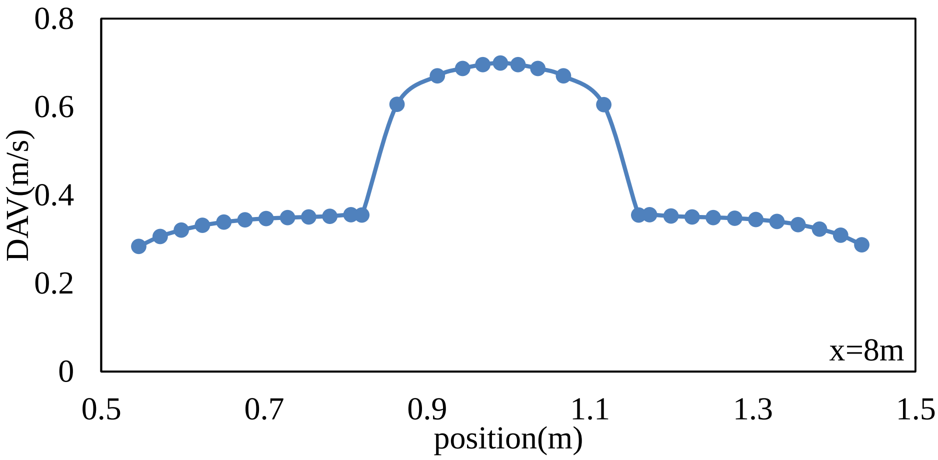

Fig 4.20 Graph between DAV and position at 8m from inlet for Dr = 0.2(ANSYS)

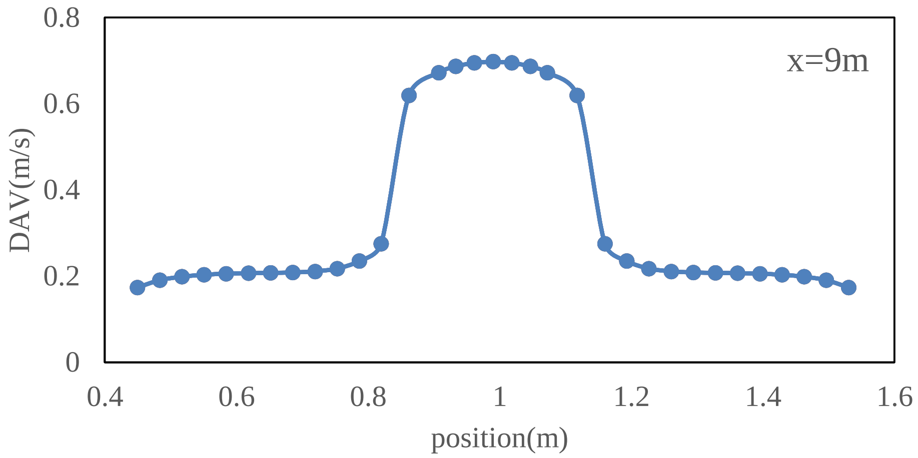

Fig 4.21 Graph between DAV and position at 9m from inlet for Dr = 0.2(ANSYS)

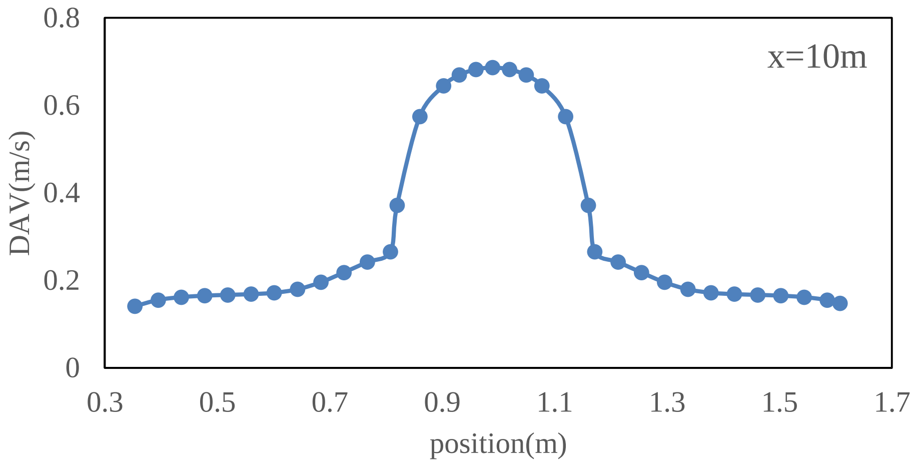

Fig 4.22 Graph between DAV and position at 10m from inlet for Dr = 0.2(ANSYS)

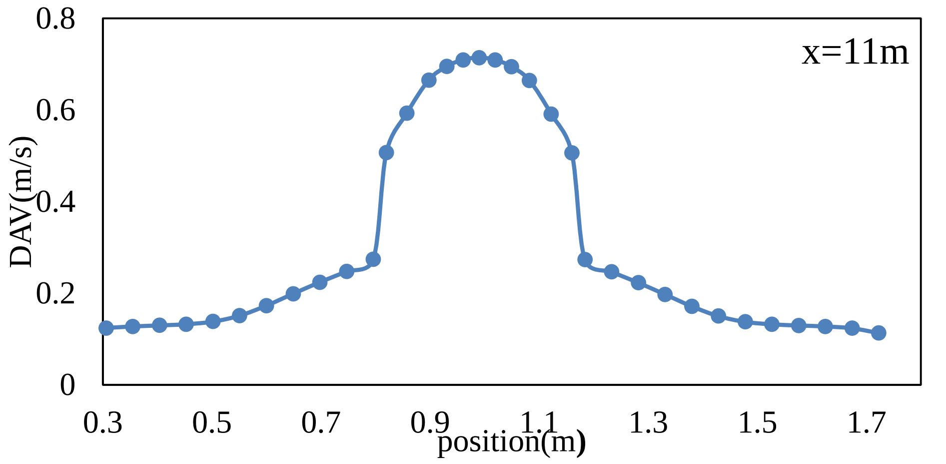

Fig 4.23 Graph between DAV and position at 11m from inlet for Dr = 0.2(ANSYS)

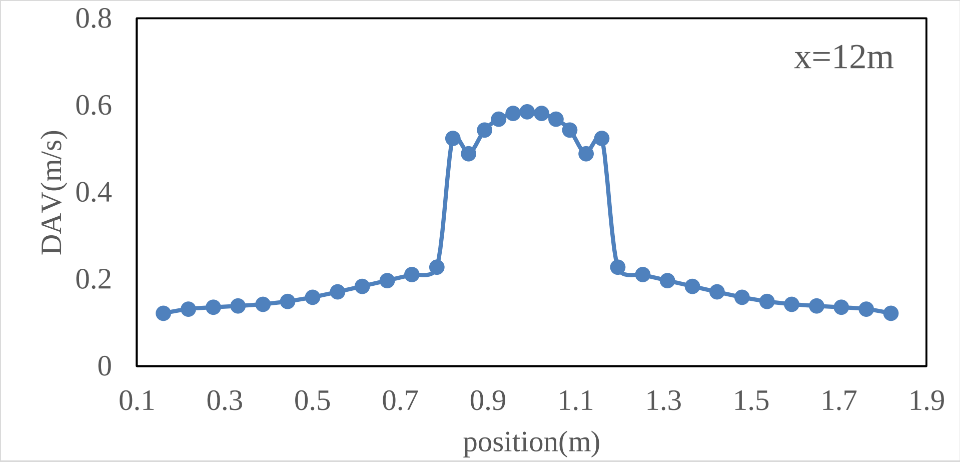

Fig 4.24 Graph between DAV and position at 12m from inlet for Dr = 0.2(ANSYS)

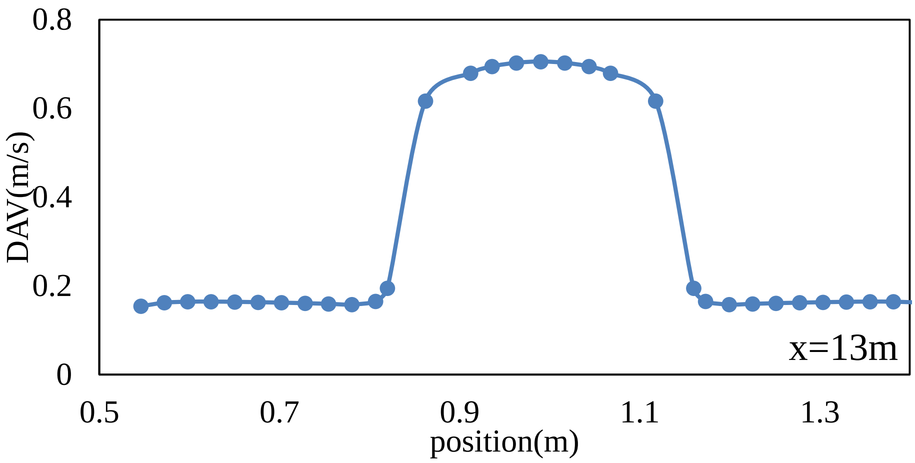

Fig 4.25 Graph between DAV and position at 13m from inlet for Dr = 0.2(ANSYS)

4.3.2 For 0.35 relative depth

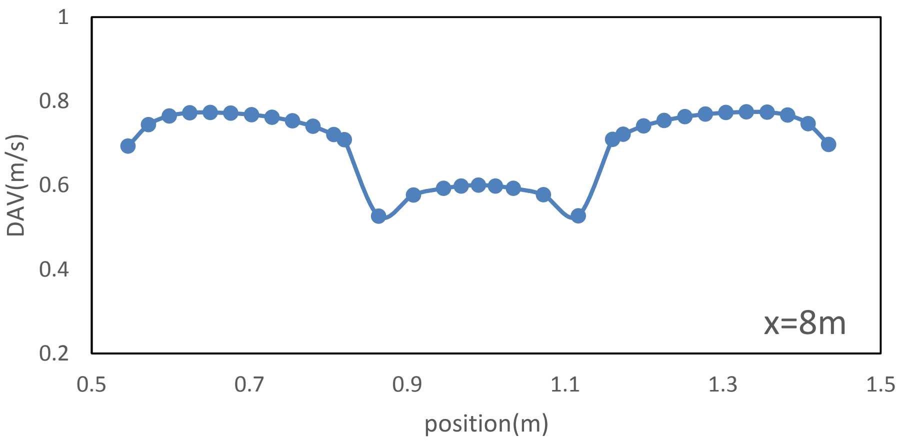

Fig 4.26 Graph between DAV and position at 8m from inlet for Dr = 0.35(ANSYS)

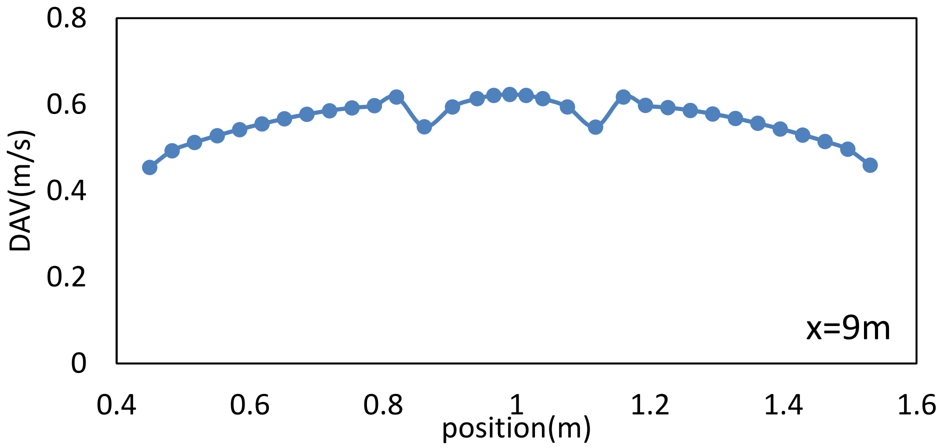

Fig 4.27 Graph between DAV and position at 9m from inlet for Dr = 0.35(ANSYS)

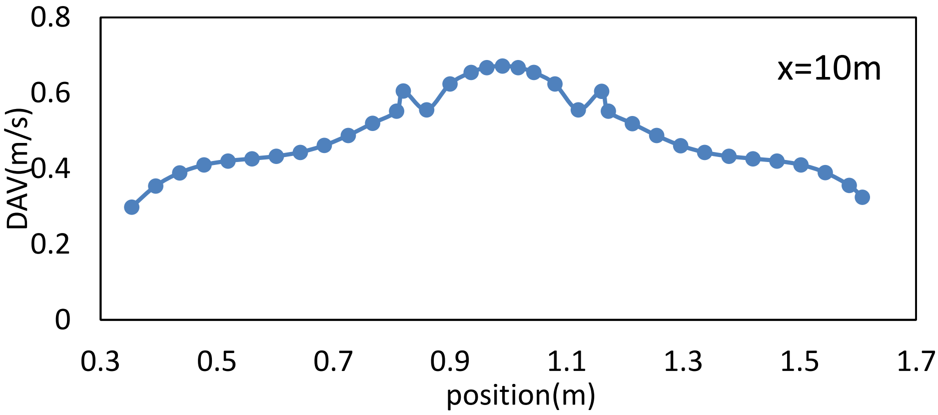

Fig 4.28 Graph between DAV and position at 10m from inle for Dr = 0.35(ANSYS).

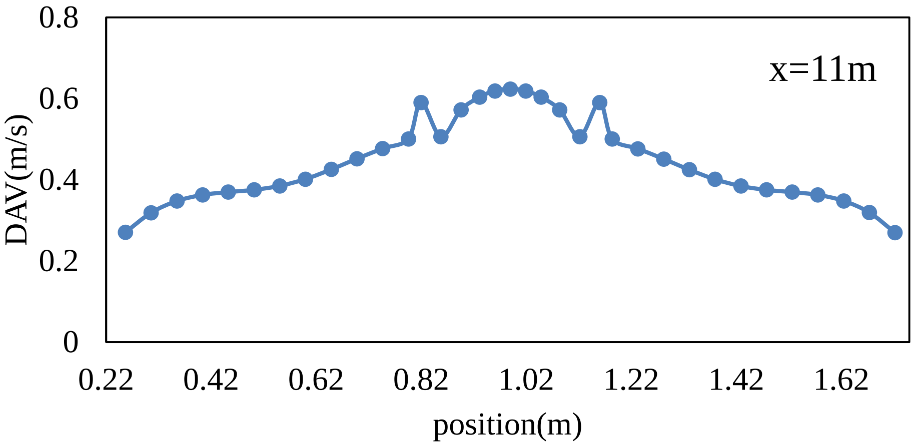

Fig 4.29 Graph between DAV and position at 11m from inlet for Dr = 0.35(ANSYS)

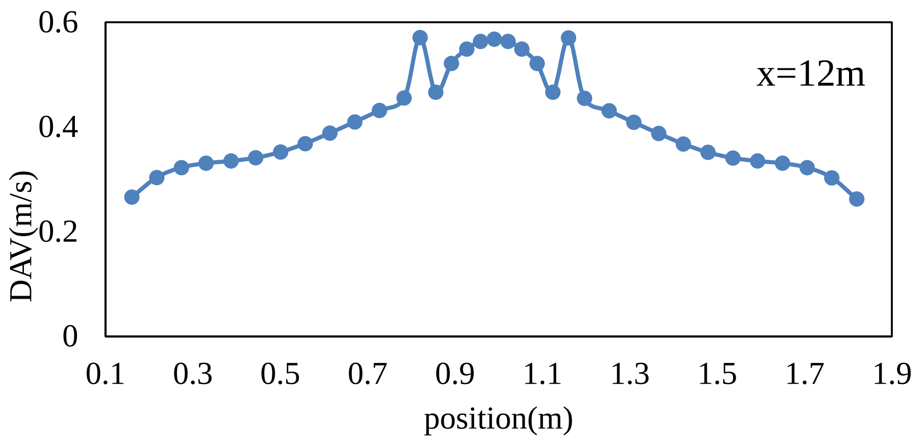

Fig 4.30 Graph between DAV and position at 12m from inlet for Dr = 0.35(ANSYS)

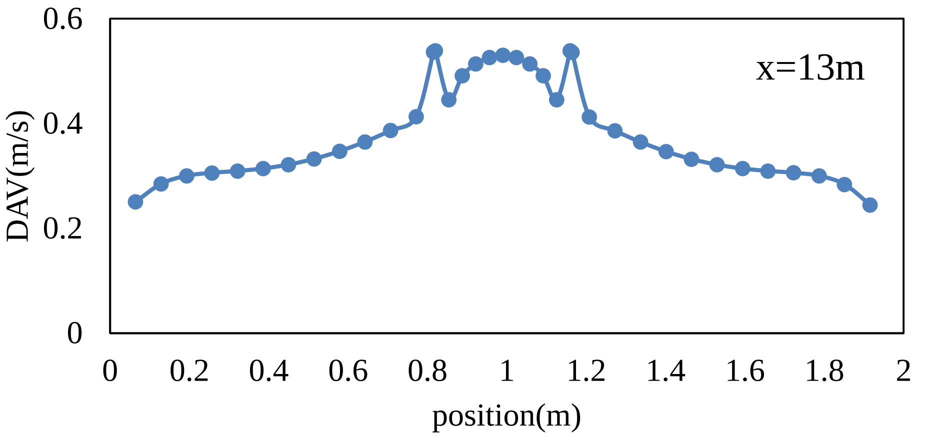

Fig 4.31 Graph between DAV and position at 13m from inlet for Dr = 0.35(ANSYS)

4.3.3 For 0.25 relative depth

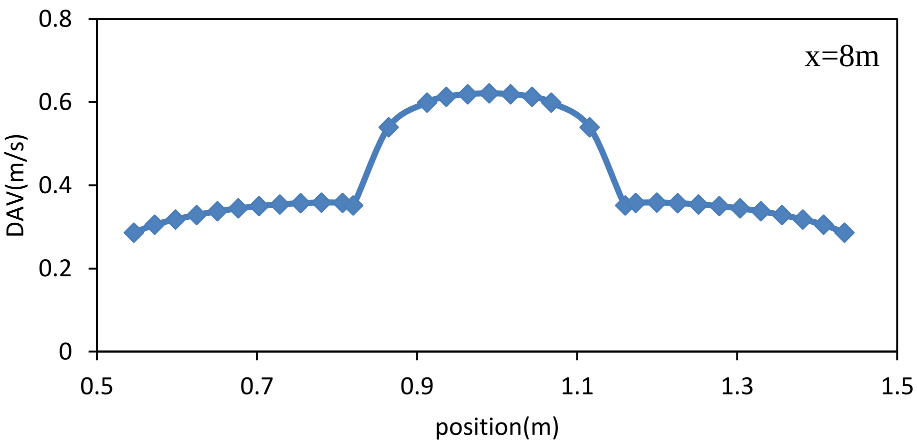

Fig 4.32 Graph between DAV and position at 8m from inlet for Dr = 0.25(ANSYS)

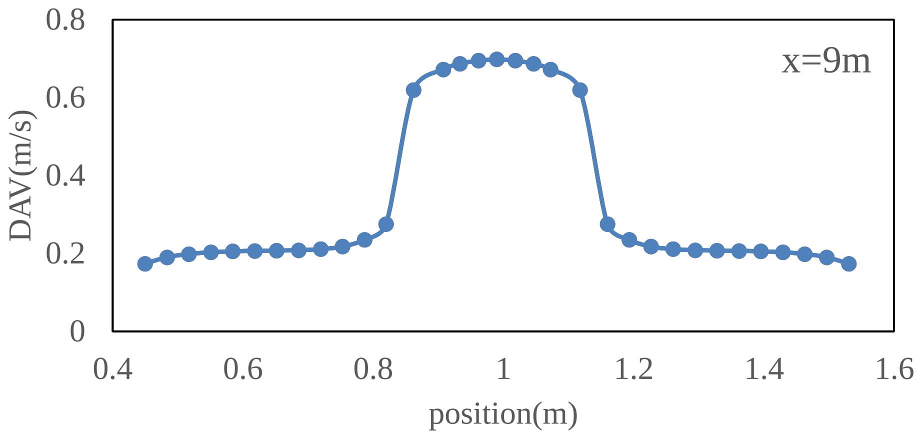

Fig 4.33 Graph between DAV and position at 9m from inlet for Dr = 0.25(ANSYS)

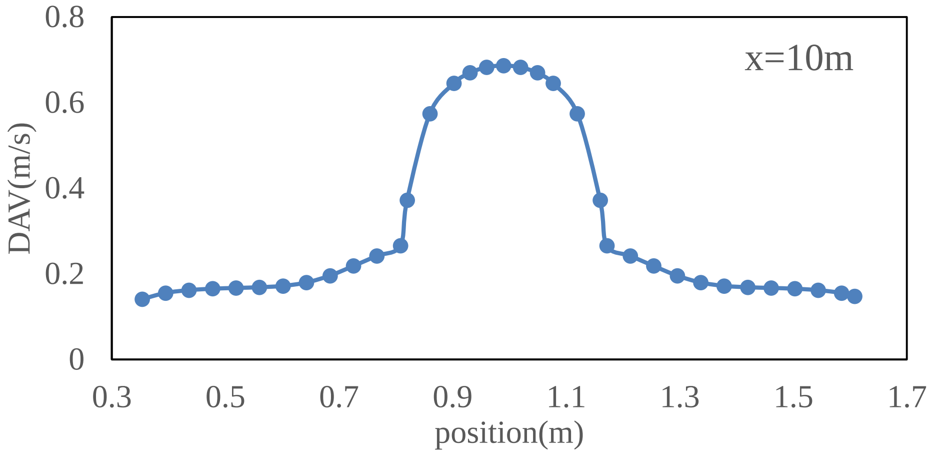

Fig 4.34 Graph between DAV and position at 10m from inlet for Dr = 0.25(ANSYS)

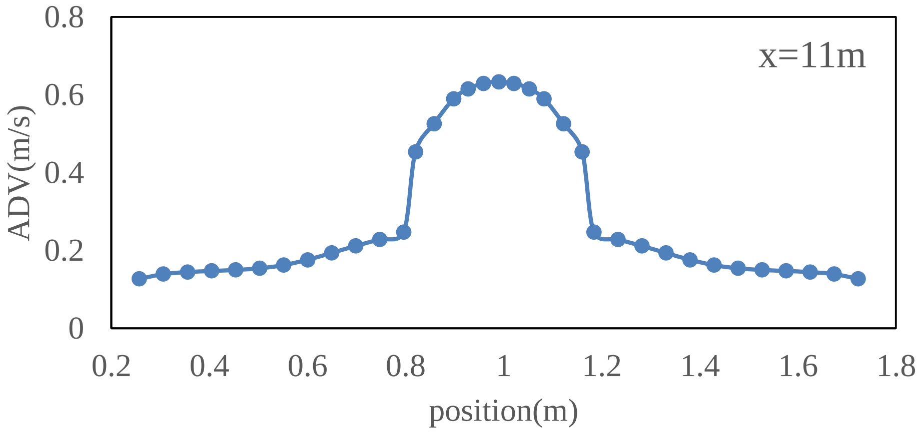

Fig 4.35 Graph between DAV and position at 11m from inlet for Dr = 0.25(ANSYS)

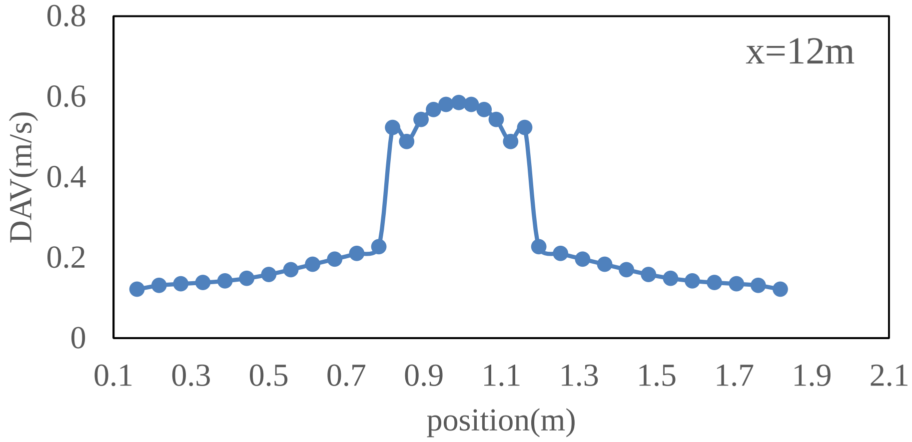

Fig 4.36 Graph between DAV and position at 12m from inlet for Dr = 0.25(ANSYS)

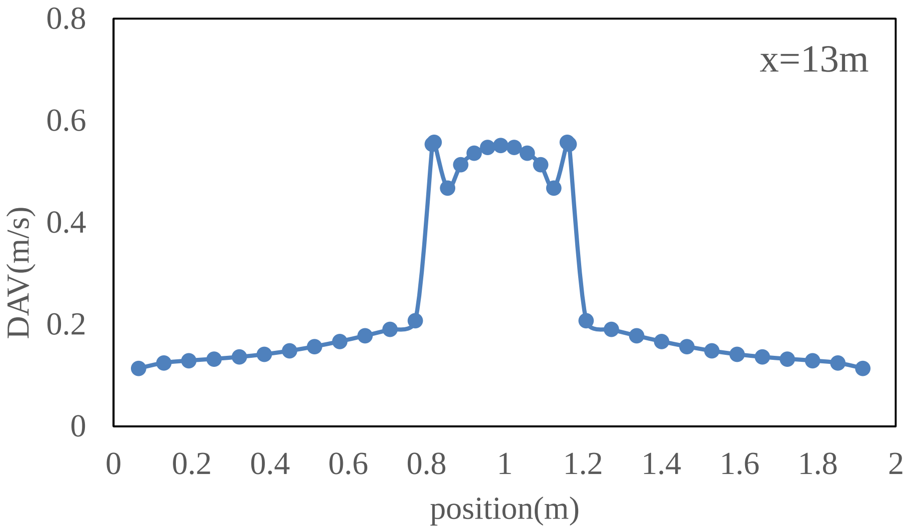

Fig 4.37 Graph between DAV and position at 13m from inlet for Dr = 0.25(ANSYS)

CHAPTER 5

EXPERIMENTATION RESULTS

5.1 OVERVIEW

In this chapter the experimental data from the other experiments and current research data about variation of DAV along the width of the channel is represented in the form of graphs and also the comparison of results between two researches has been made, we found some similarities between the two projects work.

5.2 EXPERIMENTAL DATA FROM THE OTHER RESEARCHES

Yonesi et al. (2013) represent the channel configurations by a notation as follows:
Non-prismatic (NP), diverging angle, roughness, relative depth as NP-11.3-1-0.25

5.2.1 for roughness = 1

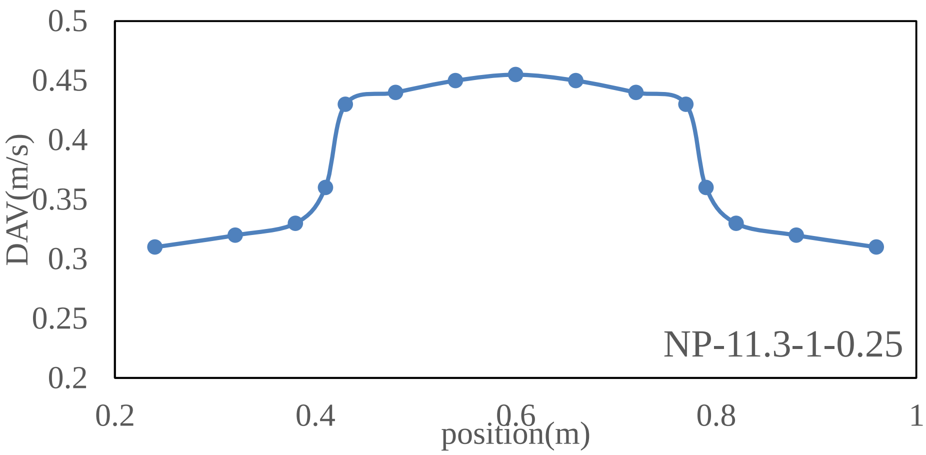

Fig.5.1 Graph between DAV and position for roughness factor =1(EXP)

5.2.2 for roughness = 2

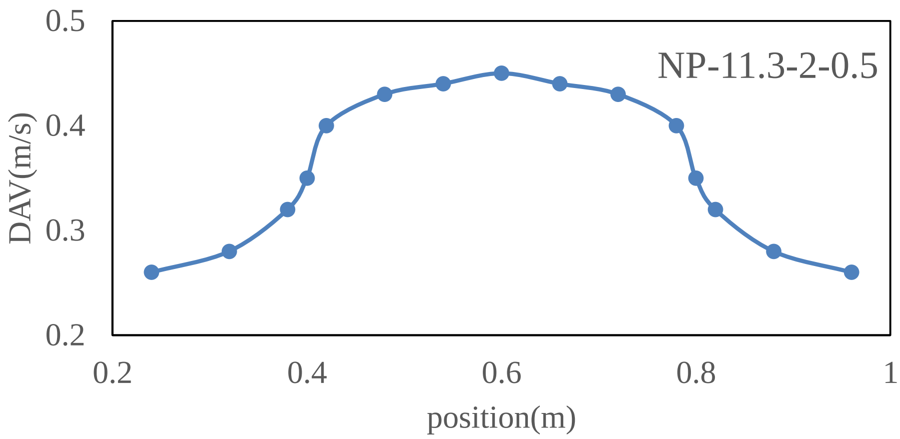

Fig.5.2 Graph between DAV and position for roughness factor =2(EXP)

5.2.3 for roughness = 2.74

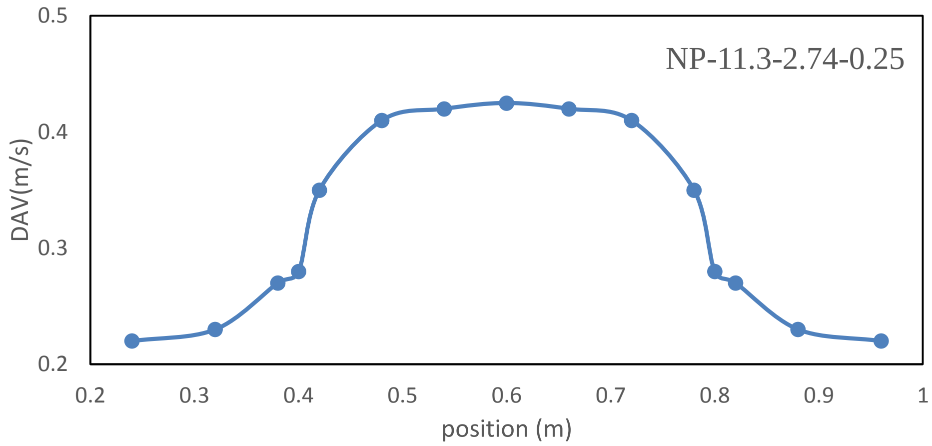

Fig.5.3 Graph between DAV and position for roughness factor =2.74(EXP)

5.3 EXPERIMENTATION RESULTS

Experimental data is collected in two ways:

1. Through the means of Pitot tube, differences in the head of static and dynamic pressure is collected. The pitot readings are taken at an intervals of one minute. This difference in head, Δh is used to compute the difference in pressure. The inclination of the Pitot tube is considered in the calculations of the velocity of the flow.

2. Acoustic Doppler Velocitimeter (ADV) is used to record velocity components in three different directions. Two have been used for measuring the velocities one is up probe and the other one is down probe. The ADV needs minimum 5cm of water depth is required for detecting the water flow and measuring due to this reason two ADV's are required for covering full depth of the channel .Three thousand samples of velocity are recorded at each point of the section and averages of these samples are taken to calculate the DAV(Depth Averaged Velocity)

Similar graphs are made (like ANSYS) from the experimental data variation of Depth averaged velocity is shown across the width at different sections 8m , 9m , 10m , 11m , 12m , and 13m from the inlet for various relative depths like 0.2 and 0.35.

5.3.1 For 0.2 relative depth

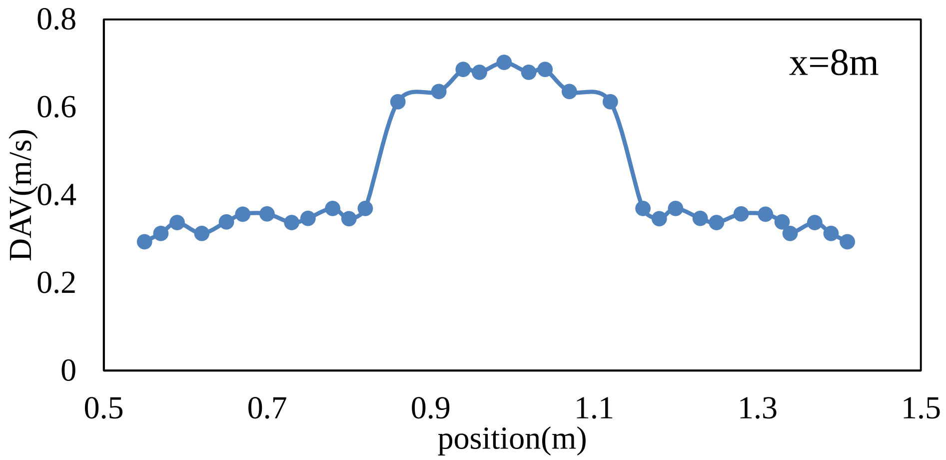

Fig.5.4 Graph between DAV and position at 8m from inlet for Dr = 0.2(EXP)

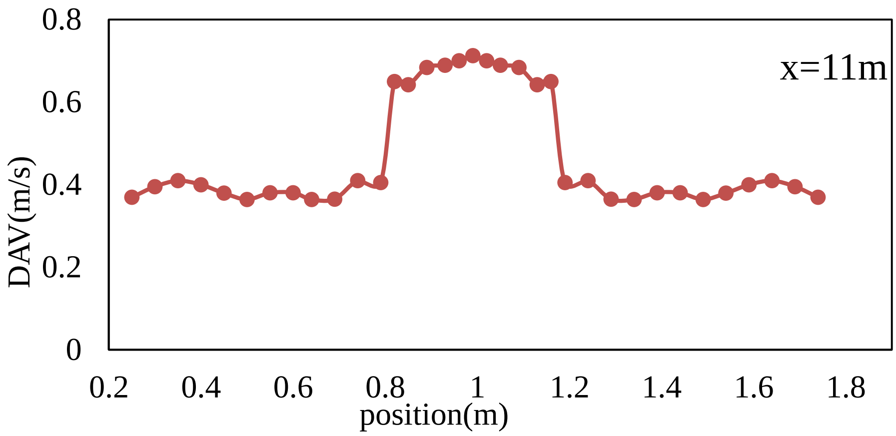

Fig.5.5 Graph between DAV and position at 11m from inlet for Dr = 0.2(EXP)

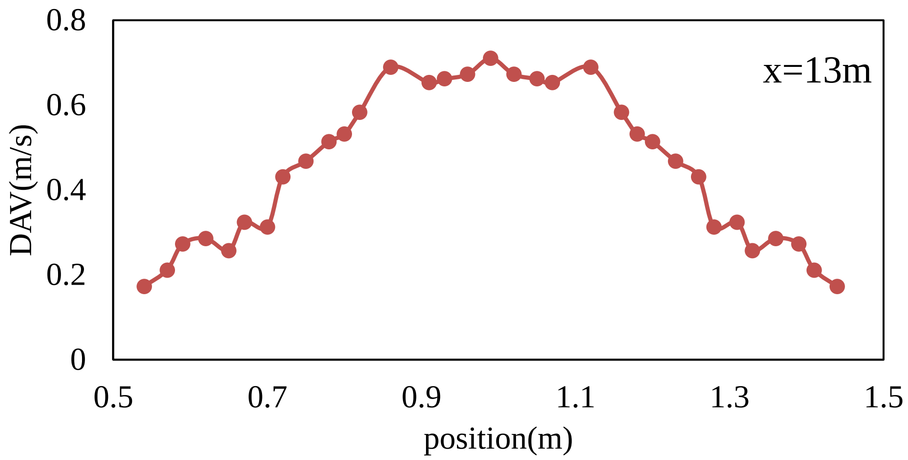

Fig.5.6 Graph between DAV and position at 13m from inlet for Dr = 0.2(EXP)

5.4 COMPARISION BETWEEN OTHER RESEARCHER'S AND CURRENT RESEARCH DATA

For other research data there is a trend of gradual increase of Depth Averaged Velocity (DAV) from flood plain to main channel of the section. There is similarity in the variation of DAV for all the three roughness 1, 2 and 2.74.The minimum DAV is observed near the boundary of the section and maximum DAV is observed at the mid-section of the main channel

Our current experiment setup has roughness 1 and we have observed similar trend of variation of DAV along the width of the channel like the results from the other research data, that is minimum DAV is observed at the boundary in the flood plain and maximum DAV is observed at the mid-section of the main channel. There is only a small variation between current research data and the other research data in case of minimum and maximum DAV at the boundary and mid- point of the main channel

CHAPTER 6
RESULTS AND DISCUSSIONS

6.1 RESULTS AND DISCUSSIONS

Comparison has been made between the ANSYS and experimental results by overlapping the Depth averaged velocity graphs at each section of channel to validate the results of k-ε turbulence model which is used in ANSYS analysis.

6.1.1 For 0.2 relative depth

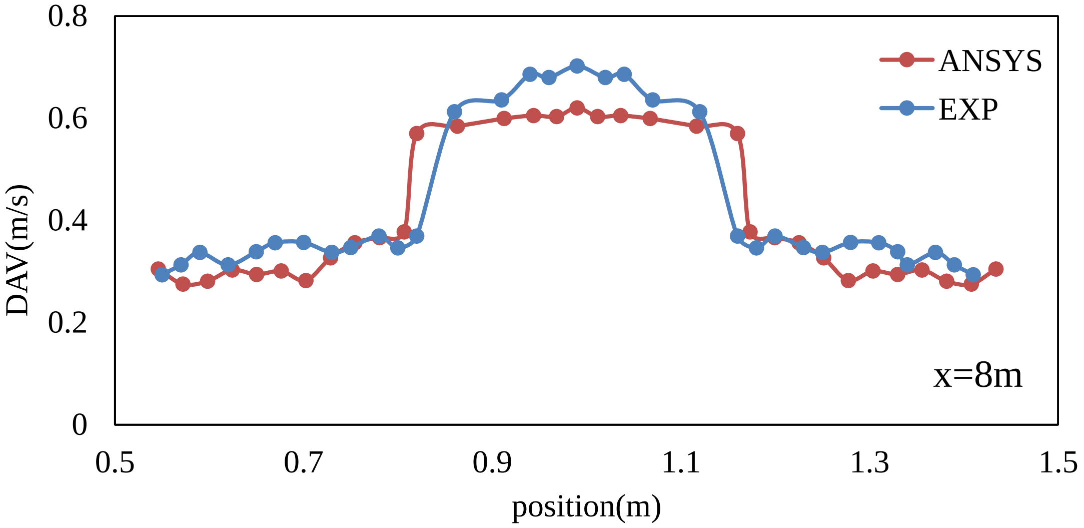

Fig 6.1 Comparison between ANSYS and experimental results at 8m from inlet for Dr = 0.2

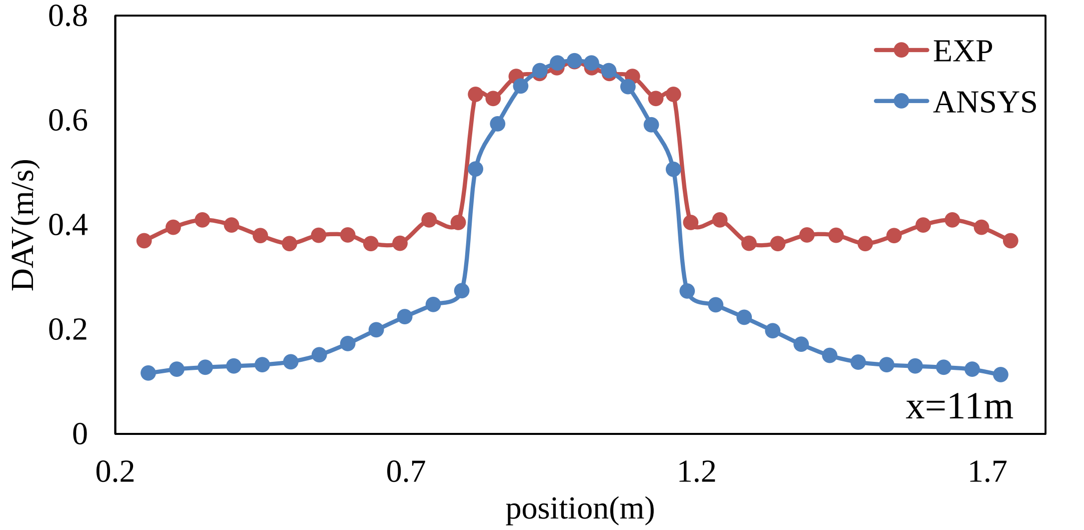

Fig 6.2 Comparison between ANSYS and experimental results at 11m from inlet for Dr = 0.2

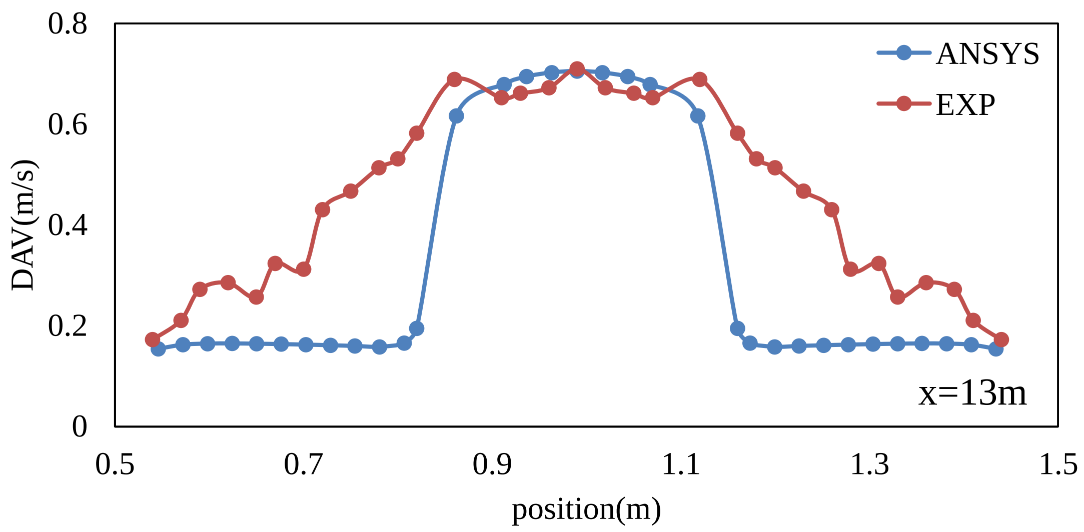

Fig 6.2 Comparison between ANSYS and experimental results at 13m from inlet for Dr = 0.2

After being plotted the graphs from the data extracted from the ANSYS as well as from experimental data and comparing them with each other we found that:

(i) At 8m section: The graphs are coinciding at the floodplain of the section but not at the main channel and there is a variation in the peak velocity of experimental and ANSYS data, the peak velocity of the experimental data is higher than the ANSYS analysis.

(ii) At 11m section :In this case it is quite opposite to the results that we observed for the 8m section, here the graphs are coinciding for the main channel part and not all matching at the floodplain section. In both the cases that is experimental results and ANSYS analysis the peak velocity is same and the graphs are perfectly matching at the peak.

(iii) At 13m section : In this case there is a lot of variation between ANSYS and experimental results at the flood plain section but the velocities are matching for the main channel part and in both the cases the peak velocities are same.

6.1.2 Discussion on ANSYS results

For 0.2 relative depth the minimum DAV is observed at the boundary and maximum is observed at the midpoint of the main channel. This is because of shear stress stresses at the boundary minimum DAV is observed and also due to lesser water depth at the flood plain and maximum DAV is at the midpoint of the channel is due to lesser shear stresses and more water depth than at the boundary of the channel. The similar trend of gradual increase in DAV from boundary to main channel is observed at all the sections of the channel

For 0.25 relative depth have similarities with 0.2 relative depth observations. In similar gradual increase in DAV from boundary to main channel is observed at all the sections of the channel except at the 12m, and 13m sections. For these two sections maximum DAV is not observed at the midpoint of the section there is a reduction in DAV at the midpoint of the main channel .This is due to these sections are far away from the inlet and also the effect of divergence of the section caused the velocity to decrease at these sections . Turbulence of flow of water also responsible for the non-linear increment of velocity from boundary to main channel.

For 0.35 relative depth the results are completely contrast with other relative depth except the floodplain part. The minimum DAV is observed at the boundary point for all the sections and maximum DAV is observed at different points for different sections.

CHAPTER 7

CONCLUSIONS

7.1 CONCLUSIONS

After being plotted the graphs from the data extracted from the ANSYS as well as from experimental data and comparing them with each other we found the results are mainly matching at main channel of sections at both 11m and 13m sections and there is some similarities between ANSYS and experimental results at flood plain of 9m section .In all the three sections peak DAV is nearly same for both ANSYS and experimental results. As the peak velocity of the main channel is one of the main criteria in designing the water channels, k- ε model is somewhat helpful in predicting the flow of compound channel having the diverging section. But this is not an ideal method to adopt completely

It is quite complicated with this results to comment on the accuracy of k-ε turbulence model in predicting the flow parameters (Depth Averaged Velocity) of diverging compound section. It is better to do the experiments for different diverging sections having diverging angles 10 and 14 degrees and for different relative depths. So that it gives us complete and perfect picture of the accuracy of k-ε turbulence model in analyzing non-prismatic diverging compound channels.

7.2 SCOPE FOR THE FUTURE WORK

Similar comparison between ANSYS an experimental results for 6 and 14 degrees could be helpful to validate the accuracy of k-ε turbulence model in analyzing flow parameters (Depth averaged velocity, boundary shear stress) of non-prismatic diverging compound channel.

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